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male, from Elk River. The variations in color of under parts do not seem to depend on age, sex, or season, though of course the fur is everywhere longer and more dense in winter than in summer, as is the case in all northern *Arvicolæ.*

*General Remarks.—Arvicola minor* is so different from all American *Arvicolæ* except *austerus* that comparison with others is unnecessary. Lest, however, there should be any question as to its distinctness from "*A. cinnamonea*" of Baird, which is said to have come from Pembina, I have measured the skull of the type (No. 591, male, U. S. National Museum—the skin has been lost), and find it to be as large as that of *austerus* proper. And Baird's measurements of the animal show that it was larger even than average *austerus.* The dental peculiarity pointed out by Baird as one of the distinctive characters of the supposed species, namely, the fact that the angular depressions in the crowns of the back upper molars communicate across the teeth, forming transverse loops instead of lateral triangles, I incline to agree with Coues in considering abnormal.

# ON ARCTIC CHARACTERS OF THE SURFACE FAUNA OF THE BAY OF FUNDY, AND THE CONNECTION WITH A THEORY OF THE DISTRIBUTION OF FLOATING MARINE LIFE.

BY J. WALTER FEWKES.

SEVERAL naturalists have shown a similarity between the fauna of the Bay of Fundy and that of the waters of Labrador and Greenland. This comparison is of great interest to students of New England marine zoology.

As the evidence thus far adduced is mainly drawn from studies of littoral animals, it has seemed in place to test the theory by a consideration of oceanic genera. It would be pre-eminently fitting to consider floating marine life with this thought in mind, and as the young of a large number of marine genera are free-swimming, it would be well to include them with true oceanic genera in this connection. I undertake this comparison with more enthusiasm, as it has been my good fortune to examine and publish notices of nomadic animals which have been collected in high latitudes by Lieutenant Greely, and since it has been possible for me to study the marine life of Grand Menan and the islands off the coast of New Brunswick.[1]

A study of the surface life of the Bay of Fundy reveals interesting facts in the theory of the Arctic relationship of the life of these regions.

Nomadic animals which live in the high seas, generally upon the surface of the ocean, are known as pelagic animals, and constitute what is called the pelagic fauna. While this fauna is preeminently the fauna of the ocean and is found best marked at a great distance from the land, it often happens that winds and currents sweep its members into our bays and harbors, and we in this way become familiar with it. Like all large bays with open access to the ocean, the Bay of Fundy has a pelagic fauna. It is, in fact, the same or nearly the same as the pelagic fauna of the coast of Greenland.

Animals which are strictly pelagic are never limited to the coast, to the littoral fauna, or to the sea bottom. They never become attached, but crawl about, or rest upon the sea floor. A large number of marine animals have young which resemble pelagic organisms in these nomadic habits. They also wander about and are carried hither and thither by ocean currents independent during their youth of the coast or the sea bottom. As they reach maturity, however, they sink to the sea floor, and there remain, either attached or limited in their movements to a small area. These young or larvæ, as they are called, may also be included in the pelagic fauna as long as they preserve this free-swimming feature. This larval and adult pelagic fauna differs in different regions of the ocean, and that of the Bay of Fundy differs in a marked manner from that of the bays of southern New England.

A study of the pelagic fauna of the Bay of Fundy shows that it has a boreal character. While it is in many respects like that of

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[1] I have already elsewhere (Bull. Mus. Comp. Zool., vol. xiii., No. 6) considered the boreal relationships of the medusan fauna of the Bay of Fundy.

Massachusetts Bay, it is in marked contrast with that of the bays south of Cape Cod. We may, in fact, say that the fauna of the Bay of Fundy is more closely allied to that of the coasts of Greenland, as far as its pelagic life is concerned, than it is to that of Narragansett or Buzzards Bay. The reason for this diversity in the inhabitants of bodies of water so near together, and the resemblances of faunæ of localities so far apart, may easily be found in the direction and character[1] of oceanic currents to which the distribution of marine life is almost wholly due. Moreover, the surface life is in a measure dependent on the amount of water brought to the coast by the tides. The greater the volume of water which sweeps into the bay, the larger the number of animals which it brings with it, if other conditions remain constant. The great tides of the Bay of Fundy are admirable for the purpose, and they bring to the shores of New Brunswick a wealth of surface life seldom equalled and never excelled elsewhere on the coast.

There is a strict line of demarcation between the surface fauna found south of Cape Cod and that immediately north of the same headland. It would seem the most natural thing in the world that an animal which passes its life floating or swimming on the surface waters of the ocean should live equally well in Narragansett Bay or the Bay of Fundy. That is, however, not the fact, for while stragglers from the true Arctic faunæ of the waters of New Brunswick may sometimes be found at Newport, there is as marked a difference in the facies of the faunæ of the two regions as between those of the two sides of the Isthmus of Panama. Why is there this difference?

The answer is found in those limitations in the distribution of animals brought about by the differences in the temperature of the sea. Everyone who has tried the ocean bathing in these two localities knows how much warmer the surface water south of Cape Cod is than that of Grand Menan, and this difference of temperature means life or death to the delicate creatures which live in it. The animals south of Cape Cod are those of warmer waters, and some of them have their home in the Gulf Stream, while those in the Bay of Fundy are pre-eminently of polar origin, and can endure with impunity a fall in temperature which would kill the inhabitants of the Gulf of Mexico. As the study of animals which are not nomadic teaches that those of the Bay of Fundy are most closely allied to the inhabitants of the colder waters of the Arctic,[1] so it is with the surface life. Both tell one and the same story, that the assemblage of life in the sea which constitutes the fauna of the Bay of Fundy is Arctic in its affinities. To demonstrate the Arctic character of the free-swimming life of the Bay of Fundy would seem to necessitate a minute comparison of faunal lists from the two localities. It is not wholly necessary for our present purposes, however, to make such an extensive comparison. Some of the more striking instances of floating boreal life will suffice.

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[1] The boreal life of the Bay of Fundy is thought to be due to the Labrador current.

Of all floating animals the jelly fishes are well suited for this study. Among the Medusæ we have marine animals, as well known as any, from which to test our theory. The following may be mentioned as some of the Medusæ of the Bay of Fundy which are markedly Arctic. The large and beautiful *Cyanea arctica*, one of the most stately forms of discophorous jelly fishes, is pre-eminently an Arctic genus. *Callinema*, first described by Professor Verrill, another large Medusa of the same group, and has never been seen south of Cape Cod. Among Hydromedusæ the beautiful *Turris episcopalis* is boreal in its distribution, and rarely gets south of the coast of Maine. *Staurophora* and *Halopsis* are northern genera. The beautiful "sea necklace," *Nanomia cara*, one of the most exquisite genera of marine animals, has been seen in the icy waters of Robeson's Channel by Arctic navigators. It is rarely seen south of Cape Cod, in Narragansett Bay, but at Grand Menan hundreds of specimens, some of which were four feet in length, were taken from the landing places, and at other points on the shore.

If we, in fact, take the faunal lists of the Medusæ of the Bay of Fundy and compare them with those from Greenland and neighboring waters, we find, as far as our knowledge goes, a strong resemblance between the medusan life in the two regions. Of course there are genera occurring in the waters of Greenland which are not to be found in the Bay of Fundy, and *vice versa*, but that does not change a belief in a general statement that the marine animals of the two localities resemble each other in facies. If we should carry our comparisons of the surface life of the two localities among other groups, we should find as marked a similarity there as among jelly fishes. One or two examples may suffice for illustration.

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[1] The surface animals of the Bay of Fundy, although Arctic, are not supposed to be of the extreme polar types. For obvious reasons little is known of the facies of polar marine life.

There is no pelagic mollusc which is more truly boreal than the well-known *Clione borealis.*[1] This pteropod rarely ventures into Narragansett Bay, is more common as we go north, and was at one time observed in great abundance in the Bay of Fundy. In the North Atlantic and on the shores of Greenland it is found at times in countless hosts.

Among the pelagic annelides, one of the most common at Grand Menan is a species of *Sagitta,* which bears a strong resemblance to a *Sagitta* found in Lady Franklin Bay by Lieutenant Greely. This Arctic *Sagitta* is markedly different from the *Sagitta* of Narragansett Bay.

The species of Appendicularia found in the Bay of Fundy is different from that of Newport, and appears to be the same as that recorded by Murdoch from Point Barrow. This pelagic ascidian, as is well known, is found in some places enclosed in a gelatinous envelop called the "*haus,*" which serves as its protection, or for other purposes. Although I have repeatedly taken Appendicularia in Narragansett Bay, I have never found the "*haus*" in those waters. From Murdoch's description of the Arctic Appendicularia and from its size, I am inclined to think that the Bay of Fundy Appendicularia[2] will also be found with houses. The mere fact alone that the Arctic Appendicularia has the house, so-called, is not characteristic, for animals of this or allied genera in warmer waters have the same structures.

The resemblances between these two marine faunæ suggest interesting general questions of distribution. Students of the geographical distribution of terrestrial animals easily recognize the facies of organic life from different continents. A collection of the land animals of Australia has an altogether different appearance from one from Europe, while those from South America are different from those of North America. While the characters which impart this difference are hard to define, they exist and are recognizable by a specialist. In the Museum of Comparative Zoology at Cambridge this difference is shown by faunal assemblages of life from different regions of the globe, each arranged in different rooms, known as the North American, European, African, etc. The idea is a grand one, and to a student of physical geography of the greatest importance.

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[1] I have taken many specimens of the larva at Newport.

[2] It is undoubtedly true that the Bay of Fundy Appendicularia is a different species or even genus from that of Narragansett Bay. It closely resembles the genus *Oikopleura.*

As in the study of land animals there is a different facies to the assemblages of life from different quarters of the globe, so in the ocean there is a different facies in collectious of animals from different regions of the sea. Place side by side a number of Arctic species of shells and those of the same genera from the tropics. If the shells be representative, the conchologist need not hesitate long as to their homes. The dull, cold, little variegated molluscs of the Arctic contrast markedly with the brilliant, gaudy shells of the warmer zones. Passing to the inhabitants of the ocean, the deep-sea animals have an altogether different facies from the surface animals. The characteristic facies of great regions of the ocean are as noticeably different as those which naturalists have long recognized among terrestrial animals. It is not in place here to point out the different regions into which the oceanic faunæ may be divided, but it would be interesting in considering the causes of the boreal character of the pelagic life of the Bay of Fundy, as they involve a general consideration of the laws which have led to the diversity of these faunæ. I consider the temperature of the water as a most important influence in causing the diversity of life in the ocean. Variation in temperature is probably more important than pressure in the bathymetrical distribution of deep-sea life. The difference in temperature of the surface of the ocean is one of the most important factors in determining the character of pelagic organisms. As we have a variety in surface temperatures, we have a diversity in the surface fauna. We have, it is held by some, a repetition of Humboldt's law of the modification of plants in altitude, and the correspondence of latitude with altitude, in a change in character of animals by depth resulting from several conditions, among which may be mentioned pressure and temperature. Whenever the temperature of the deep-sea becomes a surface temperature, as in the Arctic Ocean, then, it is argued, we may look for allies of deep-sea animals.

The two great tendencies at work in the modification, as in the geographical distribution, of pelagic animals, are cold currents of water bringing them into lower and warm currents transporting them into higher latitudes.[1] The physical result in both instances is a change in the temperature of the water and other conditions in which they live. Where the currents generally set from the south to the north, as on the eastern coasts of the Northern Hemisphere, we may expect a relationship to the tropics in higher latitudes than where the currents are from the pole. The former currents carry the warm belt into higher, while the latter restrict it to the lower latitudes. It is known that the distribution of coral reefs on the western and eastern coasts of the continents has a direct relationship to the direction of the ocean currents, and that where the current is from the equator to higher latitudes (Eastern coasts) coral reefs extend farther from the equator than where the general direction of the oceanic rivers is from colder to warmer latitudes.[2] This can readily be seen by consulting a map of the earth's surface where all the great coral reefs are on the eastern side of the continents, and where also all the great oceanic currents are setting from the equator towards the poles.

This law in the distribution of corals, pointed out by Dana, is believed to hold also in the case of other animals, which, unlike corals in their mode of life, are not fixed, and have left no hard secretions to denote their former or present existence.

It will be seen by a consultation of Krümmel's maps of the distribution of surface temperatures in the Atlantic, and by a reference to the chart of the surface temperatures published in *Science* for December, 1887, that the Bay of Fundy does not lie in the same isothermal zone as do the waters of the coast of Greenland. Perhaps these zones were only intended as approximations, and the temperature of the water of the Bay of Fundy may not be higher than of that of the coast of Newfoundland. In the chart referred to, the Bay of Fundy is near the southern limit of the zone of low surface temperature, and the high tides may account for the large percentage of boreal surface animals in its waters.

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[1] The pelagic life washed to the coast of England will probably be found to differ from that of Labrador under the same latitude.

[2] Possibly due also to the food of the coral, minute floating life, which is furnished in greater abundance on account of the currents.

The student of the geographical distribution of pelagic life will, I believe, find a correlation between the facies of this fauna and the zones of equal temperatures of the sea. An improvement in the projection of these zones on the maps of oceans will lead to a corresponding advance in our knowledge of the distribution of marine life characteristic of the surface of the sea. If we accept the proposition that the pelagic fauna of the Bay of Fundy is Arctic in its facies, it becomes an interesting thing to study carefully this fauna in its relation to animals found in deep-sea.[1] Is there a closer affinity between animals found on the surface of the ocean, where the water has an Arctic temperature, and those of the deep water where the temperature is the same, than between those of the surface of the ocean in the tropics and deep water, where there is a marked difference in temperature? Although marine zoology has never been a primary object of polar exploration, it is probably true that most interesting results are to be looked for if the attention of Arctic explorers is turned to the importance of this study. Let me call to mind one interesting aspect of the study of marine animals from polar regions. Now that the character of the deep-sea fauna may be said to be known, as far as its general facies is concerned, it may be well to ask whether there are any places on the globe where conditions found in deep water are repeated in shallow seas, and where there is a similitude in the environment under which life exists.

There are two conditions under which deep-sea life is placed which may be considered. The first of these is pressure, a condition which we can normally expect to find only in the sea at great depths; the second is a low temperature of the water which exists in certain oceans at the surface.[2] A third condition, viz., the amount of light, is in a way connected with the second. In my consideration of the subject it is not discussed.

[1] The explanation advanced by physical geographers that cold waters near land are sometimes due to a replacement of surface waters by those from great depths may explain many peculiarities in the distribution of life.

[2] Murdoch's record of pelagic animals taken from the Arctic Ocean when the temperature was 29.1° F., is among the most valuable which have been made on the character of pelagic life in water of this low surface temperature. If they are not the first observations on this subject, they are certainly the most complete.

In many invertebrate animals the difference in pressure at 1000 fathoms and at one fathom is endured with impunity by the same species. Difference in pressure under which a deep-sea animal is placed is not believed to be the influence which is most important in the determination of the limitation of deep-sea faunæ to certain depths.

Invertebrate animals, however, which can endure equally well enormous pressures or live near the surface without harm, are delicately susceptible to a change of temperature of a few degrees. Temperature has drawn even in littoral zones invisible limits or lines of demarcation, which are partially known to naturalists. The laws of the diminution in heat with the depth has also been shown. It is known that the bottom temperatures of deep-seas are surface temperatures in some parts of the globe. If temperature. is an important condition of the environment of deep-sea animals, it is significant to discover what the character of the marine life is in latitudes where the temperature is that of the deep sea and where it is constant.

The polar oceans show on the surface of the water the low temperatures of the deep seas. Those temperatures, to find which in tropical oceans the plummet has to go many fathoms below the surface here come to the surface, and are its ordinary temperature

It is interesting to discover whether in places widely separated in latitude, but where the temperature of the sea is the same and constant, we find any uniformity in the ocean fauna. It must be recognized that we have in the great body of water which composes the ocean a mass of liquid, the temperature of which is modified by local currents, vicinity to the land, and other conditions. As a general law, to which there are some exceptions, it may be said that the temperature of the sea decreases as we sink below its surface. Of all places in the ocean, where the limits of variations in temperature are small, none equals the deep water. A maximum variation in the tropics may be found on the surface and in the neighborhood of the coast line. The minimum is far below the surface in the deep water.

It may readily be imagined that, if there were no distribution of heat in the ocean by currents as we go north or south from the equator, we should find the isothermobatric lines, or lines of equal deep-sea temperature, gradually approaching the surface of the sea until we come to the icy waters of the pole. Here we should find a law of the distribution of heat similar to that which holds on land, where there is a constant relationship between the altitude above the level of the sea and the latitude as far as the diminution in temperature is concerned, unless modified by local conditions. As we ascend the tropical mountain the heat, as a general thing, diminishes; the same is true as we go below the ocean. As we increase our latitude in either case, the temperature follows a common law in its change, approaching *pari passu* the level of the sea.

It was long ago recognized that the distribution of plant life on a tropical mountain is correlated with the change in temperature, and that in ascending a tropical mountain-side we pass through the three climatic zones. The author does not know how far this theory is now accepted by botanists, but it is interesting to see whether a similar law holds in the ocean where there is a like change in temperature. We know that there is a peculiar fauna of those animals which habitually live on the bottom in the deep sea. We know there is an æquatorial marine life which is confined to the surface of the ocean, represented by *Physalia*, *Velella*, and others. Associated with the latter are other genera, as *Atolla*, which sometimes go down to 1800 fathoms below the surface. Are there any medusæ at 1800 fathoms which rise to the surface without destruction? I think there are, although our facts are not decisive enough to prove it.[1] I also believe that there are nomadic deep-sea animals which in the tropics cannot rise through the stratum of warm water above them without harm, but it by no means follows that where these low temperatures of the deep seas become surface temperatures they may not come to the surface of the sea.

It seems probable that the cold areas of deep seas have preserved uniformity of environment for a much longer period of time than warmer areas of the surface. The water of the ocean in different strata is, of course, varying its temperature, but there are certain positions where an almost uniform temperature has been kept up for long periods of time. The uniformity of conditions in the cold polar seas, as far as temperature of the water goes, is greater than under the equator at the surface. Consider the waters of the polar ocean covered by a palæocrystal ice, and those unprotected under the burning tropical sun. In the one there is certainly a minimum of variation in temperature, in the other a maximum, as far as the water is concerned. If environment, if uniformity of conditions, has anything to do with variation in forms of life or with the preservation of ancestral features through long periods of time, should it not appear in the animals which live under these conditions?

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[1] Since this was written a large number of observations by Chun have shown the truth of this belief.

There is a certain parallelism in the animals of cold and warm oceans and those of deep seas and littoral zones. It is, of course, impossible to link together what we know of deep-sea life with that of the polar region with any hope of a satisfactory answer as long as our knowledge of either is incomplete. Fortunately the character of deep-sea life in late years has been investigated. As far as this problem goes, the least satisfactory part is that which pertains to the *nomadic* deep-sea genera. With regard to the marine life of the polar regions, where the deep-sea temperatures become surface temperatures, much remains to be done. We know the littoral marine Invertebrata of the polar sea better than those of many bays contiguous to our own country, but the subject of the marine surface fauna is yet to be more fully investigated. If polar exploration is to be continued, as there is no doubt that it will be, a more complete study of the marine life would be an important object of such exploration, and would be of value to our knowledge of the geographical distribution of marine animals. It would be interesting to take up again the somewhat threadbare discussion of a relationship between the Arctic and deep-sea faunae. It might verify a prediction that it is possible to recognize ancestral forms among those which people the icy waters of the polar seas. The theory of the Arctic character of deep-sea faunæ is by no means a new one, and as long as the zone of deep water from 100 to 300 fathoms was studied there seemed to be a marked likeness between these two faunæ. When, however, the variegated fauna of the abysses of the ocean came to be studied, it became more difficult to found resemblances between deep-sea animals and those of the poles. Our comparison of deep-sea floating life with the polar introduces a new phase in the discussion, as the animals which we are considering are not attached, but are nomadic in nature. There is nothing to prevent a comparison between the nomadic life of deep water and that of the Arctic, even if the facies of the abyssal zone is different from that of any oceanic fauna of the globe. While the difficulties in the investigation of the animals of the polar regions are such that much remains yet unknown in relation to the surface life of these latitudes, the similarity of that of the Bay of Fundy to it, if such a likeness really exists, renders this study comparatively easy. It becomes imperative, then, to know accurately the facies of this fauna if one would use this knowledge in comparisons with deep-sea faunæ.

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# CEREBROLOGY AND THE POSSIBLE SOMETHING IN PHRENOLOGY.

BY S. V. CLEVENGER, M.D.

TEN years ago, in the *American Journal of Nervous and Mental Disease*, I reviewed the history of brain studies, from Erasisratus to Ferrier, and described the convolutions and fissures with their equivalent names as used by English, German, French and Italian investigators. Microscopic details had at that time added immensely to our knowledge of the structure of this important organ, but since then pathological and physiological science has corrected many of the errors prevalent and improved our understanding of the localization of function.

When it was established that arm, leg, tongue, ear and eye centres were distributed about the brain cortex, beneath alleged bumps of conjugality, appetite for music, theology and onions, phrenology was discouraged except among its more ignorant devotees. At the conclusion of a popular lecture on the anatomy and physiology of the brain I was assailed by an itinerant phrenologist who did not relish his dollar-a-head prospects being jeopardized by the spread of my heresies. He offered to stake money on the infallibility of his "science" in a public demonstration, and when told that phrenology had been written up in a form available for criticism and